

# Evaluating the university campus soundscape: The case of Tianjin University

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## Summary

The university campus outside environment occupies an important position in the daily life of students, providing a place to relax and restore psychologically, to study and to perform social activities. A fitting soundscape therefore contributes to the mental well-being of students and may help to foster academic performance. Proper ways to evaluate the quality of a university campus soundscape, taking into account acoustical and perceptual aspects, are essential. This paper reports on the results of a soundscape study performed on the Qilitai campus of Tianjin University, China. As a first step, the distribution of sound levels over the campus was investigated on the basis of sound measurements at various locations on the campus, during all periods of the day. Sound maps helped to delimit black spots on the campus. As a second step, a perception study was performed among university students. Individual soundwalks through the campus were carried out during which, at several locations, participants had to fill in small questionnaires. The latter contained questions on sounds that were identified and on cognitive and affective judgments of the soundscape. Results of this survey are presented in this paper, and suggestions for improvement of the campus soundscape are formulated.

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## 1. Introduction

The outside environment of a university campus has a great influence on students, in particular if they are living on campus. Previous research on the soundscape of teaching/learning environments has mainly focused on the influence of indoor noise sources and their effects, thereby giving advice on potential improvement of the indoor environment. For example, surveys conducted in Turkey and Brazil by Kurra [1] found that the most annoying indoor noise was caused by human activity, followed by noise from electrical equipment noise. Dockrell and Shield [2] found that teachers and students are most affected outdoors by traffic noise, and indoors by neighbor noise, based on a study in 142 schools in London.

Research and control methodologies for indoor acoustic environments have achieved some merit, and are being used widely in colleges and universities nationwide in China. However, up to now, relatively lit-

tle attention is being paid to the outdoor acoustic environment on university campus environments [3, 4]. This paper reports on the results of a soundscape study performed on the Qilitai campus of Tianjin University, China. Both acoustical (sound level distributions) and perceptual aspects (individual soundwalks with questionnaire survey) are taken into account.

## 2. Methodology

### 2.1. Overview of study area

The Qilitai campus of Tianjin University has a trapezoid shape with an area of about 2 km<sup>2</sup>. A map of the campus is shown in Figure 1. The stationary time schedule of teaching hours at the university is listed in Table I. Road traffic forms the major source of noise on the campus. Traffic counts at the main eastern gate of the campus show a traffic intensity of around 2000 vehicles over the course of the rush hour period. In total, 24 noise monitoring locations were selected, based on the principle that the distance between measurement locations should not be more than 150 m. An overview of the measurement locations is



Figure 1. Map of the Qilitai campus of Tianjin University.

Table I. Time schedule of classes at Tianjin University.

Class	1	2	3	4
Start	08:00	09:55	14:00	15:55
End	09:35	11:30	15:35	17:30

also shown in Figure 1. The western and northwestern parts of the campus contain housing for the family members of working staff, whereas students and teachers are mostly active in the eastern part. Therefore, the sound monitoring locations are mainly distributed in the eastern area, considering that the main users of the campus are students and teachers.

## 2.2. Sound level measurements

The sound pressure level was measured at each monitoring location simultaneously using a set of 24 Japan ONO SOKKI sound level meters, which were mounted on a stand of 1.2 m height. Measurements started at 6:40 am and ended at 19:40 pm, whereby the sound pressure level was recorded every 20 minutes. Hence, 40 values of  $L_{Aeq,20min}$  are available, covering the sound level during a single day.

## 2.3. Soundwalks

As the main objective of this study is to investigate the advantages and disadvantages of the campus design on the its soundscape, soundwalks were performed on the campus as a way to take into account the influence of the visual scenery on soundscape perception [5]. A special focus was placed on three important areas of the campus (see Figure 2): the office and teaching area (area 1), the dormitory area (area 2), and the public area (area 3). During the soundwalks, participants had to fill in 3 small questionnaires, one for each type of area that was walked through. In total, 64 participants (38 males, 26 females) performed a soundwalk, mainly students of Tianjin University, living on the campus. The soundwalk route contained three parts, through the three different areas, shown in Figure 3. The questionnaire consisted of three sections: a section with questions on sound perception

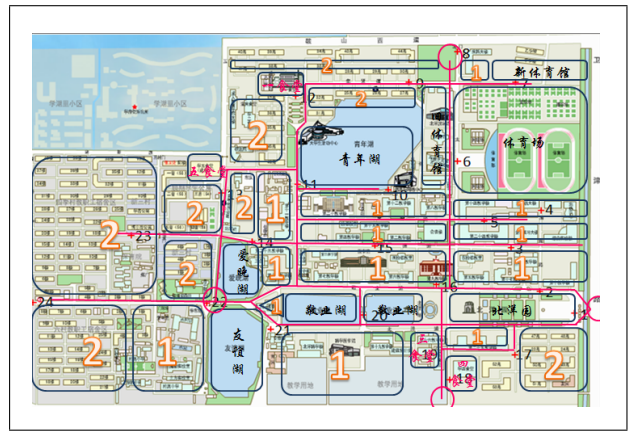


Figure 2. Three types of areas of the campus: office and teaching (labeled 1), dormitory (labeled 2), and public area (all other areas).



Figure 3. The route of the soundwalk.

and preferences, a section with a semantic analysis of the soundscape [6], and an evaluation of the road traffic on campus.

## 3. Results

### 3.1. Sound level distribution

Table II shows the measurement data (daytime and 20-minute sound levels, and standard deviation of the 20-minute sound level) at the 24 locations. As can be seen on Figure 1, the measurement locations were numbered in such a way that number differences give an estimate about the distance between locations, i.e. proximity numbering. Those monitoring locations which stand close to each other can be expected to have some similarities with their neighbors. This can be seen to some degree on Figure 4, in which the 40  $L_{Aeq,20min}$  values at each of the 24 locations are plotted in a three-dimensional map.

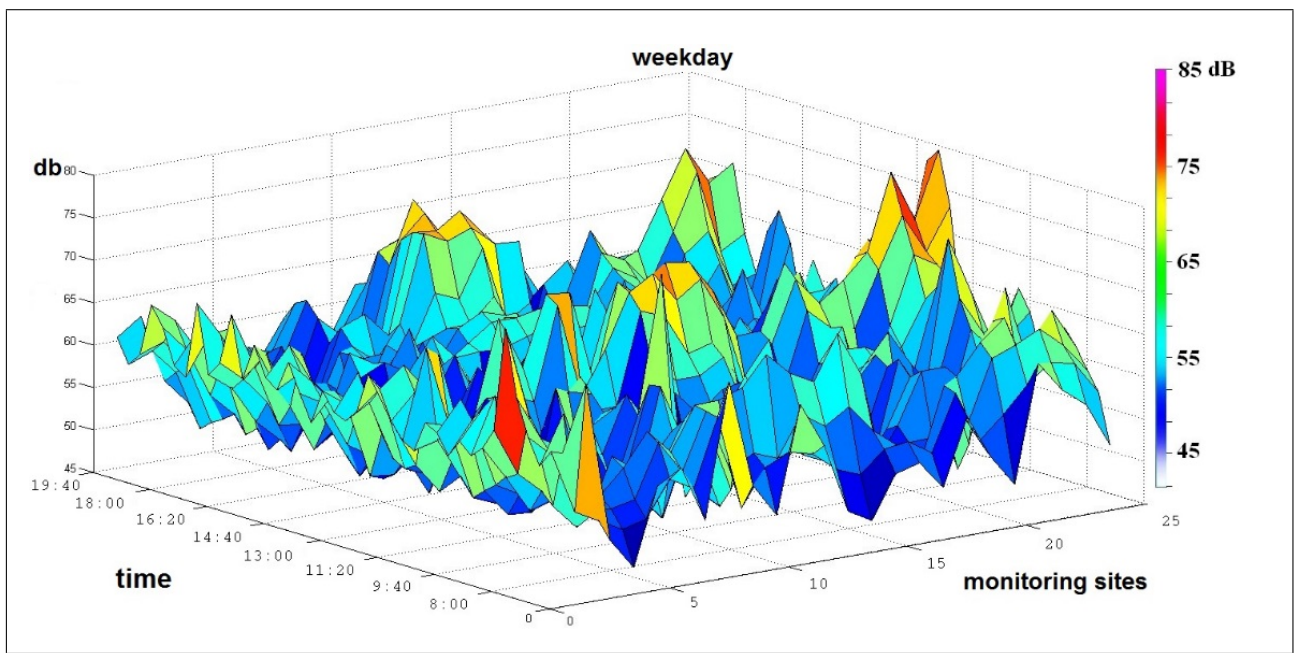


Figure 4. Time history of  $L_{Aeq,20min}$  for the 24 monitoring locations from 6:40 to 19:40.

Table II. Measurement data at the 24 monitoring locations. Sound levels are given in dB(A). For the area type, the options are (P) public, (D) dormitory and (T) teaching and offices.

Point	$L_{Aeq,day}$	$L_{Aeq,20min}$	Std.dev.	Area type
1	61.5	57.2–75.2	3.5	P
2	61.5	54.6–70.1	3.2	P
3	55.9	50.3–67.0	3.7	T
4	51.5	47.5–57.5	2.3	T
5	53.9	47.7–61.4	3.6	T
6	56.4	51.2–69.4	3.6	P
7	55.1	51.0–63.2	2.9	P
8	61.1	55.3–71.3	3.3	P
9	57.3	51.2–76.4	4.7	D
10	55.2	46.3–64.5	4.3	P
11	61.6	53.1–71.2	5.1	P
12	62.0	55.1–72.4	4.7	P
13	61.8	49.7–72.5	5.0	D
14	61.0	48.1–72.1	5.2	P
15	57.7	49.7–68.2	4.5	T
16	52.9	48.7–62.4	2.7	P
17	54.9	50.1–62.5	3.2	D
18	60.3	53.5–70.0	3.8	P
19	58.7	52.1–65.2	3.3	P
20	56.8	49.2–67.4	4.7	P
21	59.9	52.1–70.2	5.1	P
22	64.3	55.6–79.1	5.5	P
23	62.2	54.5–73.1	4.6	D
24	63.8	52.1–80.7	6.0	D

There are four clear peaks in Figure 4, which are all above 70 dB(A). These correspond to monitoring locations 12/13 (gateways of the restaurants) and 21/22 (west gate of the campus), at around 11:40 and 17:40. On the basis of Table I, it can be derived that these

are rush hours, during which students go to restaurants to have their meals or go to the dormitories. The peaks in sound pressure level are thus associated to the student activities and flows on the campus. Furthermore, a number of other black points with high sound pressure level can be discerned from this graph. As can be seen on Figure 2, office and teaching areas are relatively concentrated, whereas dormitory and public areas are relatively spread. Teaching and office areas generally have the lowest sound pressure levels. The situation for public and dormitory areas is less clear; measurement locations at the western edge of the campus are subject to the highest levels, with peaks in  $L_{Aeq,20min}$  of more than 80 dB(A).

The fourth column of Table II shows the standard deviation of  $L_{Aeq,20min}$  at each monitoring location. Based on the Pareto principle, a threshold on the standard deviation can be drawn at 5 dB(A); the 5 points (20.8% out of 24 points) with the largest standard deviation are 11, 14, 21 (all crossroads), 22 and 24 (gates of the campus). At these locations, the variation in flow of vehicles and people is largest, and these locations therefore should draw special attention for soundscape management. From Figure 2, one finds that these locations are situated mostly on the boundaries between functional areas. The time history of  $L_{Aeq,20min}$  for this selection of monitoring locations over the course of the day is shown in Figure 5; the peak hours around 11:40 and 17:40 are clearly visible on this graph.

In summary, it is found that teaching and office areas that are located on the boundary of areas labeled 1 are subject to the highest sound pressure levels. The concentrated location of dormitories at the west side

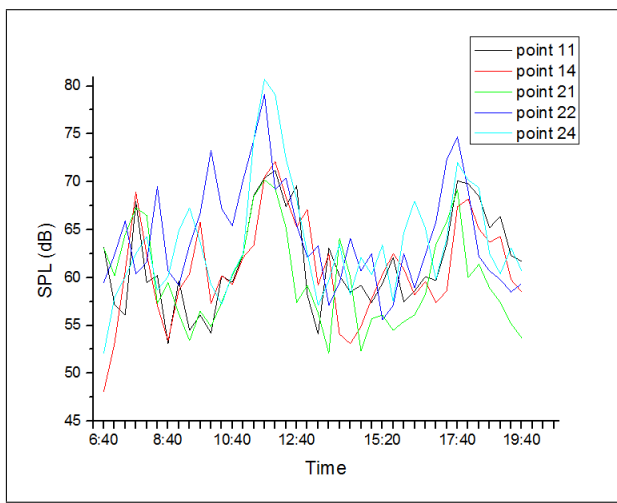


Figure 5. Time history of  $L_{Aeq,20min}$  for a selection of monitoring locations: 11, 14, 21, 22 and 24.

of the campus may have its merits regarding cost saving and ease of management, but it also results in heavy rush hour traffic of pedestrians, bikes and vehicles. Consequently, the west gate of the campus is subject to relatively high sound pressure levels, due to the amount of traffic and the presence of a loud road surface.

### 3.2. Sound perception and preference

The first section of the questionnaire administered to the participants consisted of questions on the presence and preference of sounds. A preliminary investigation of the campus soundscape showed that there are 13 main kinds of sounds, and these were subsequently included in the questionnaire. Figure 6 shows the fraction of participants that noted down that they heard a particular sound along each of the three different roads of the soundwalk. Birds singing, bicycles and chatter are most heard along road 2, whereas wind, vehicle noise and whistle sounds draw more attention along road 3. It can be expected that, next to the actual presence of sound sources, also the visual scenery along each of the three roads influences the attention that people pay to particular sounds.

Figure 7 then shows the preference for each of the sounds (the order of sounds is the same in both figures), as rated on a 5-point scale ranging from -2 (not favorable) to 2 (very favorable). Clearly, the preference for particular sounds does not depend on the location on campus, there is a high correlation between the curves for the three roads; favorability to particular sounds is long formed and relatively stable. Only for the favorability to whistle, bicycle and motion sound, there is some difference between the three roads.

### 3.3. Semantic differential analysis

The second part of the questionnaire consisted of a semantic differential analysis of the soundscape. The

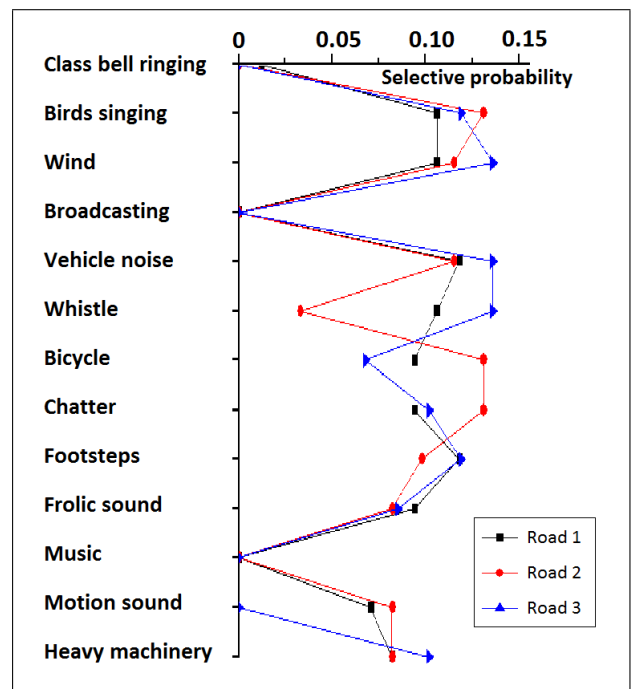


Figure 6. Perceived probability of noticing particular sounds along the three roads.

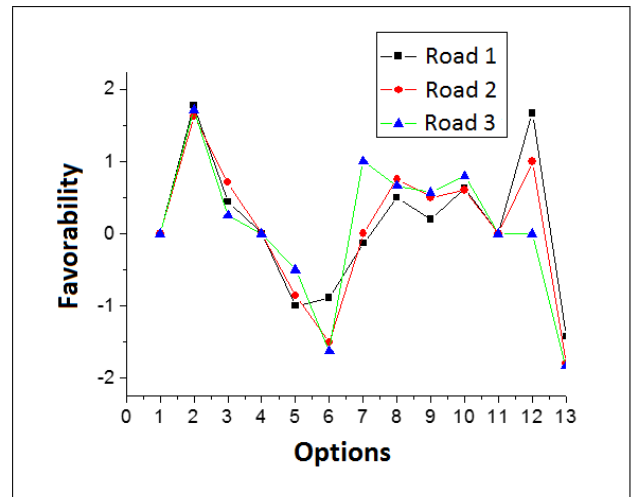


Figure 7. Preference for each of the sounds heard along the three roads (same sounds as in Figure 6).

series of word pairs used are shown in Figure 8, together with the results of the questionnaire, as rated on a 5-point scale (-2 to 2). Although mixed in the original questionnaire, the results are sorted such that words with a negative connotation are shown on the left hand side in Figure 8, to facilitate visual inspection of the results. Overall, it is clear that road 2 is appreciated most negatively. It is located in a dormitory area, and although being evaluated as quiet, bleak and turbid, which fits its purpose of rest, it is also evaluated as being more boring and depressing. Road 3 is appreciated most positively, in line with expectations for a public area.



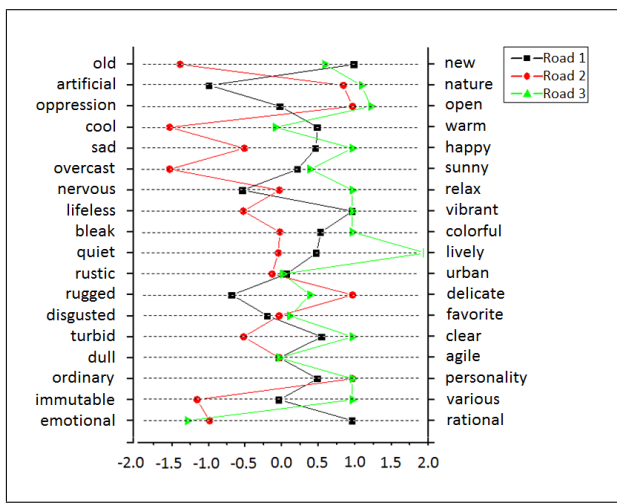


Figure 8. Results of the semantic differential analysis.

Table III. Result of the question on road traffic.

Issue	Rd. 1	Rd. 2	Rd. 3
Too many roadblocks	—	—	0.27
Too narrow road	0.04	0.50	0.09
Potholes	0.11	—	—
Too many vehicles	0.08	0.50	0.18
Too many pedestrians	0.23	—	0.09
Traffic jam	—	—	0.05
No traffic rules (pedestr.)	0.23	—	0.05
No traffic rules (vehicles)	0.08	—	0.18
Too many bikes	0.23	—	0.09

### 3.4. Road traffic evaluation

At the end of each questionnaire, a question targeted at the practical problems existing on campus was asked. Participants could signal 9 of the most common annoying problems, identified through a preliminary investigation. The results are listed in Table III. For road 2, the problems identified are that it is too narrow, and that there is too much heavy traffic. For road 1, the problems identified are mainly due to the road being shared by pedestrians and cyclists. For road 3, there is a conflict between cyclists and vehicles. These discords reflect the general grievances of the students, which are (i) that the amount of traffic on campus is too high, and (ii) that the public area on the campus is constructed as a park, which makes the traffic situation complex.

## 4. Conclusions and recommendations

In this paper, the soundscape on the Qilitai campus of Tianjin University was investigated through the combination of sound level measurements at 24 selected locations on the campus, and soundwalks among students, during which a small soundscape questionnaire had to be filled in at several locations along the walk. The distribution of sound levels over the campus was

investigated, taking into account three different areas according to their use: teaching and office spaces, dormitories, and public areas. It was found that sound levels are highest at the west side of the campus, and that these high levels are mainly caused by vehicle and pedestrian traffic during rush hours (students moving from and to the dormitories and restaurants). The questionnaire results revealed which kinds of sounds were most appreciated during the soundwalks; in general, a good agreement among participants and among locations on the campus was found. The semantic differential part of the questionnaire clearly indicated which roads were most favored by participants.

Overall, the design of the campus has its benefits. To good extent, the outside acoustic environment fulfills the expectations for a campus soundscape. Nevertheless, a number of suggestions can be formulated for improving the soundscape on the campus. Firstly, the relative concentration of teaching and office areas is acceptable on a campus, but attention should be paid at the design of the boundaries of these areas, where there is a transition into the public area, where more noisy activities can take place. A green belt could serve as a buffer to lower sound levels at the office and teaching areas. Furthermore, a decentralized localization of dormitory spaces could spread rush hour traffic, and thus lower peak sound levels. Aesthetic design of the dormitory areas could also influence soundscape perception. Secondly, the design of crossroads in the public area could focus on the use of bypasses, thereby accounting for the almost tidal regime of student movements. Finally, restricting road traffic on the campus, and installing low-noise road surfaces would most probably improve the campus soundscape quality.

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